

# **GREATER YELLOWSTONE INTERAGENCY BRUCELLOSIS COMMITTEE (GYIBC) "WHITE PAPER"**

## **BRUCELLOSIS IN THE GREATER YELLOWSTONE AREA**

One of the most difficult aspects of developing management plans for wild, free-ranging bison and elk herds in the Greater Yellowstone Area (GYA) is that some animals in these herds are hosts for the organism *Brucella abortus* which causes the disease brucellosis. *B. abortus* is endemic in GYA bison and elk, and one of ten objectives of the Greater Yellowstone Interagency Brucellosis Committee (GYIBC) is to "plan for the elimination of brucellosis by the year 2010" (see attached). However, there are differing opinions about the appropriateness or necessity of a management emphasis on the elimination of *B. abortus*, the environmental consequences of actions necessary to eradicate the disease, and the consequences of not eradicating brucellosis from these herds.

While there is public controversy about brucellosis and wildlife, professionals in the various relevant technical fields also disagree. This paper was developed to summarize the information about brucellosis, as it might relate to management of bison and elk in the GYA, about which there is general agreement among the technical experts employed by the responsible state and federal agencies.

## **WHAT IS BRUCELLOSIS?**

Brucellosis is a contagious bacterial disease, caused by various species of the genus *Brucella* that infect domestic animals, wildlife, and humans worldwide. In North America, the primary livestock hosts of *Brucella* spp. are cattle (*B. abortus*), goats (*B. melitensis*, Mexico only), swine (*B. suis*), and sheep (*B. ovis*). The principle North American wildlife hosts for *Brucella* spp. are bison and elk (*B. abortus*), caribou and reindeer (*B. suis*), and feral and wild swine (*B. suis*). Brucellosis also may occur in carnivores, including dogs, and it is usually caused by *B. canis*. Wild canids also may develop antibodies to *B. abortus* without developing clinical infections or shedding the organism.

In ungulates, transmission of *B. abortus* typically occurs through ingestion. The incubation period (the time between exposure and onset of infection) varies widely depending upon exposure dose, previous vaccination, species, age, sex, stage of gestation, and susceptibility. Following a brief systemic infection, the organism typically localizes in the udder and/or lymphatic system and, depending upon the stage of gestation, in reproductive tissues. Abortion is the characteristic sign of acute brucellosis. Other signs include retained placenta, infertility, reduced milk production, lameness, swollen joints, and swollen testicles. Microscopic lesions may also occur in lymph nodes. Following pregnancy, the *Brucella* organism may become dormant, persisting only within cells of the lymphatic system. Following a dormant period, acute infection may recur during subsequent pregnancy.

The organism is shed in aborted tissues, reproductive tissues, and discharges, especially just prior to, during, or soon after abortion or live birth. The organism also may be shed in milk for variable lengths of time. Some infected cattle, bison, and elk intermittently shed the organism.

There is no feasible treatment or cure for animals infected with *Brucella*. Some animals may develop immunity and never have the disease. Animals that overcome the clinical signs of brucellosis may develop recurrent infections and thus they may be a source of exposure and possible infection for other animals. Some animals may completely clear the bacterium. Some individual cattle are reported to have a natural resistance to brucellosis and this trait may be heritable. Natural resistance may also occur in other species. In humans, brucellosis is known as undulant fever. Symptoms include recurring fever, muscle and joint aches, headaches and nausea. Although insidious, undulant fever is rarely fatal. Human brucellosis in North America may be caused by *B. melitensis*, *B. suis*, or *B. abortus*. Other species of *Brucella* only rarely cause human disease. Strain 19, a strain of *B. abortus* used to vaccinate livestock, also may cause undulant fever when accidentally injected. People may become infected with *Brucella* by contact with sufficient organisms through exposure to infected animals and their infectious tissues. Entry into the body is through

ingestion, contact with mucous membranes (e.g. eyes), through an open wound or through intact skin. Consumers of unpasteurized milk and other dairy products made from unpasteurized milk are people at highest risk for contracting the disease. Other people at high risk include livestock handlers, slaughter industry workers, and veterinarians. If properly cooked, meat from infected animals is not a health risk to humans. Infected bison and elk are a health risk for people who either improperly handle the carcasses or may be exposed to birth tissues. The risk is greatest when handling infected females during the last half of pregnancy. This risk, however, is minimal if these people use adequate precautions, e.g. protective clothing, gloves, care with sharp instruments, and washing thoroughly after handling tissues. With progress toward eradication of brucellosis in livestock and with pasteurization of milk, the national occurrence of undulant fever in humans from all *Brucella* spp. has declined from 6,500 reported cases in 1940 to 70 reported cases in 1994. There have been no cases of human undulant fever in Wyoming or Idaho attributed to wildlife. In Montana there have been two confirmed cases of hunters contracting undulant fever from elk.

## **BRUCELLOSIS TRANSMISSION**

The primary mechanism for transmission of *B. abortus* in cattle is well understood. Typically, transmission occurs when susceptible animals come into direct contact with contaminated aborted fetuses, birth membranes, uterine fluids, or vaginal discharges from infectious animals. Ingestion of contaminated material is the primary route of infection. A female calf born to an infected dam can also become infected in utero, but will not manifest the disease until it has either aborted or calved. Infected females typically abort their first pregnancy following infection, which usually occurs during the third trimester. Thereafter, the bacteria usually localize in lymph nodes surrounding reproductive organs and the udder. Bacteria are shed in milk, aborted tissues, birth membranes, and discharges from the female reproductive tract just prior to, during, or after birth or abortion. Occasionally, the bacteria may occur in other tissues or body fluids. Transmission of *B. abortus* in elk is far less documented, but it is believed to be similar to that described above.

There is disagreement over the primary means of brucellosis transmission among bison. But, research projects now under way may help settle the controversy.

## **BRUCELLOSIS DIAGNOSIS**

Standard tests for the presence of *Brucella* antibodies in milk and blood are used to identify potentially affected herds. An affected herd is one in which one or more animals have been determined to be infected. The presence of antibodies is used as an indication of infection, particularly on a herd basis. Diagnosis is based on the results of serologic tests combined with other information, including individual animal and/or herd history, clinical signs, epidemiology, and bacteriology. The bacteriological procedures used to identify *Brucella* infection include culturing the bacteria from tissues, milk, udder secretions, aborted fetuses, and uterine discharges.

Some animals may lack antibodies but still may be infected, especially those incubating the bacteria. In contrast, antibodies may be present in an animal from which the bacteria have not been cultured. An animal with natural resistance to the *Brucella* organism that has been challenged with *B. abortus* will generally experience a short-lived antibody response. Tissues collected from these animals will be culture negative, supporting their resistance to infection. According to the UM&R, a cattle or bison herd may be classified as a brucellosis reactor herd based on test data. A herd is classified as an affected herd after *B. abortus* has been isolated from at least one animal in a suspect and/or reactor herd, or epidemiological data supports that conclusion.

Killing suspect animals generally is necessary to obtain adequate samples for bacteriologic culture. Biopsy also may be performed. This procedure is not currently a routine diagnostic technique, but is being evaluated as a research tool for studies of wild bison. Interpretation of culture results is difficult because the ability to isolate the bacteria varies with the location and abundance of *B. abortus* in the animal. The culture of *Brucella* organisms from tissue or blood is a definitive indication of infection, however, the organism may not always be recovered even though it is present. Failure to culture the bacteria may be due to inappropriate techniques, improper storage of specimens, or failure to use sufficient amounts of tissue.

It is not possible to determine, with certainty, the risk of bacterial transmission based on the results of these standard serologic and culture tests. Within a herd, the number of animals capable of transmitting the bacteria generally is less than the number of animals with positive blood tests. For regulatory purposes, a herd with non-vaccinated, seropositive animals is considered affected. The number of infected animals generally is greater than the number of animals with positive culture tests. There is no test to specifically identify all infectious animals, i.e. those animals presently capable of transmitting brucellosis. However, it has been assumed that each infected female animal will shed the organism at some time in her life. The quantity of *Brucella* organisms shed at any particular time is variable and the number of organisms that comprise an infectious dose also is variable.

## **NATIONAL BRUCELLOSIS PROGRAM**

The Cooperative State-Federal Brucellosis Program began in July 1934, under an amendment to the Jones-Connelly bill (Public Law 142). At that time, a cattle reduction effort was launched on a national scale in response to drought. The reduction emphasized elimination of animals with disease. The program consisted of blood testing of herds and removal of infected animals. All states cooperated in the plan, but not on a uniform basis. The reactor rate in the tested population of adult cows was about 11.5%.

In 1947, the United States Livestock Sanitary Association (now the U.S. Animal Health Association) recognized that brucellosis should be under a national program and recommended adoption of the first Uniform Methods and Rules (UM&R) for eradication of the disease on a herd, area, state, and national basis. The rules have been revised from time to time to meet the changing needs of the program. In 1956, Congress authorized the Secretary of Agriculture to enter into cooperative agreements with individual states for a brucellosis eradication program based on the Recommended Brucellosis Eradication Uniform Methods and Rules. The UM&R describes standard procedures for surveillance, testing of suspect exposed or affected domestic cattle and bison herds, quarantine of exposed or affected herds, and restrictions on interstate shipment of cattle and bison originating in states with affected herds. Routine compliance with the UM&R is enforced pursuant to the respective authorities of the individual state animal health agencies. The UM&R is periodically revised by the U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS), in response to recommendations that it receives from state animal health authorities and the livestock industry. Since inception of the program, approximately \$3.5 billion in state, federal, and industry funds have been spent on eradication. The number of known affected cattle herds has been reduced from 124,000 in 1957 to 26 as of February 28, 1997.

The goal of the national program is to eradicate brucellosis from cattle and domestic bison by December 31, 1998. However, it is an issue of debate how this goal and the provisions of the UM&R apply to wild, free-ranging bison and elk herds that harbor *B. abortus* or to cattle herds that may associate with those bison and elk.

Although the risk is low, there is some possibility for brucellosis transmission from wild bison and elk in the GYA. While that possibility persists, the ability of Wyoming, Idaho, and Montana to comply with the provisions of the National Brucellosis Eradication Program may be compromised should *B. abortus* be transmitted from elk or bison to cattle.

## **BRUCELLOSIS IN YELLOWSTONE BISON**

By 1902, only a remnant population of wild bison remained in Yellowstone National Park. That year, 21 bison were translocated to the park from ranched herds in Montana and Texas. The current park bison herd is descended from the less than 50 bison inhabiting the park at the end of 1902.

Evidence of brucellosis in park bison was first reported in 1917 and it is assumed that the disease has been endemic since then. In various samples, a range of 40 to 54% of the tested bison was seropositive for antibodies. The relationship between serology and culture results is not well understood, but ongoing studies are being conducted to define that relationship.

The original source of brucellosis in the GYA is unknown. *Brucella abortus* was introduced to North America with imported cattle. Therefore, the bacterium probably was transmitted from domestic livestock

to bison. It is unknown exactly how and where the original transmission to bison occurred. *Brucella* isolated from bison is identical to *Brucella* that causes brucellosis in cattle. However, it does not appear that brucellosis is a threat to the long-term survival of park bison. Although brucellosis related abortions are known to occur, studies have demonstrated that the park bison population has been generally increasing, in spite of intermittent control actions outside the park, for the last thirty years.

### **BRUCELLOSIS IN MONTANA ELK**

About 1.5% of the elk in the Montana portion of the GYA herd has consistently tested positive for *Brucella* antibodies. These include the Madison, Gallatin, Gravelly-Snowcrest, Absaroka, and Northern Yellowstone herds. These elk herds are free ranging and do not utilize artificial feedgrounds. The prevalence of brucellosis in the southern elk herds is considerably higher and probably maintained at high levels through increased exposure while on the feedgrounds. The source of brucellosis in Yellowstone elk has not been identified. Six of the 104 elk harvested during the 1997 late hunt near Gardiner tested positive for brucellosis. At this time it is too early to determine what this possible change in the rate of seropositivity means.

### **BRUCELLOSIS IN THE JACKSON BISON HERD**

Bison are native to the Jackson Hole area but were extirpated by 1840. In 1948, 20 bison from Yellowstone National Park were introduced to the 1,500- acre Jackson Hole Wildlife Park near Moran. This herd was maintained at a level of 15-30 animals until 1963, when brucellosis was diagnosed in the herd. At that time, all of the adults were slaughtered. Four vaccinated yearlings and five vaccinated new calves were retained and 12 brucellosis-free bison from Theodore Roosevelt National Park, North Dakota were added to the herd.

By 1968, only 11 adult bison and four or five calves remained. They all tested negative for *Brucella* antibodies. Later that year, the bison escaped from the Wildlife Park and, subsequently, were not constrained. The herd began to increase at a mean annual rate of 18% after it began wintering on the National Elk Refuge in 1975. The bison herd numbered 255 in 1995. The bison continue to winter on the Refuge where they commingle with brucellosis-infected elk, primarily during the period when elk are supplementally fed.

The Jackson Bison Herd is currently affected with *B. abortus*. Either the presumed brucellosis-free herd included infected animals prior to escape or bison became reinfected after association with elk on the National Elk Refuge. The seroprevalence rate of 35 bison collected during herd reductions in 1989 and 1990 was 77%. Four of eleven (36%) seropositive bison collected in 1989 were cultured positive.

### **BRUCELLOSIS IN THE JACKSON ELK HERD**

The Jackson Hole and Gros Ventre valleys historically were winter ranges for elk that today comprise the Jackson Elk Herd. When homesteaders arrived in Jackson Hole in the 1890's, the number of elk that wintered in this area varied between 15,000 and 25,000. During summer, the Jackson Herd is distributed across an area of about 2,100 square miles including the National Elk Refuge, Grand Teton National Park, the southern portion of Yellowstone National Park, portions of the Bridger-Teton National Forest, and including the Teton and Gros Ventre Wilderness Areas, portions of the Targhee and Shoshone National Forests, and other state of Wyoming lands.

A large portion of the traditional elk winter range was settled by the beginning of the 20th century. Large numbers of elk died and excessive depredations on haystacks occurred during several severe winters between 1889 and 1911. The National Elk Refuge was established in 1912 as a winter elk range for the purposes of reducing winter losses and offsetting impacts to homesteads.

The Jackson Elk Herd winters on: 1) the National Elk Refuge (24,700 acres), administered by the U.S. Fish and Wildlife Service; 2) three feedgrounds in the Gros Ventre River drainage that are managed by the Wyoming Game and Fish Department; and 3) native winter range in the vicinity of Grand Teton National

Park and the National Elk Refuge. The population objective is 11,029 elk with 7,500 on the Elk Refuge, 2,400 on the state feedgrounds, and 1,129 on native winter range. The 1996 Jackson elk population exceeded 16,000 animals.

One consequence of feedgrounds is the concentration of many elk on limited winter ranges during the period when brucellosis-induced abortions typically occur. Correspondingly, the feedgrounds provide an unnatural, but ideal, environment for the transmission of *B. abortus* among elk. There is opportunity for exposure to *B. abortus* on the National Elk Refuge where aborted fetuses of both bison and elk occur. Brucellosis was diagnosed in elk from the National Elk Refuge when the first tests were conducted in 1930. Because no prior testing had been done, it is not known how long the disease had existed in this herd. Nor is it possible to determine with certainty how elk acquired the disease. Presently, about 28% of the Jackson Elk Herd and 38% of its adult females test positive for antibodies to *B. abortus*. Although the actual abortion rate is unknown, it has been estimated that 7% of the expected annual calf crop from this herd is lost due to brucellosis-induced abortion. Nonetheless, under current management practices that include public hunting, the Jackson herd increases at a mean annual rate of about 20%.

### **BRUCELLOSIS IN WYOMING ELK FEEDGROUNDS**

Wyoming operates 22 elk winter feedgrounds that are distributed between Big Piney and the Gros Ventre River drainage. These were established to mitigate the loss of winter range and to prevent damage to private hay crops. Three of these feedgrounds support portions of the Jackson elk herd. The remainder supports more than 19,000 elk from the Afton, Fall Creek, Hoback, Pinedale, Piney, and Upper Green River herds.

Presence of *B. abortus* has been confirmed by serology or culture from aborted fetuses at 18 of the 22 state operated feedgrounds. Although prevalence varies among state feedgrounds, about 30% of the tested adult female elk have been seropositive.

Normal and healthy calving of elk occurs in seclusion and cows meticulously clean up birth membranes. These behaviors significantly reduce the potential for transmission to other animals, including elk, but are not usually associated with abortion. Maintenance of brucellosis in elk apparently requires disruption of normal calving behavior, as occurs when infectious cow elk are concentrated on winter feedgrounds and abortions occur.

### **BRUCELLOSIS IN IDAHO ELK**

An estimated 2,800 elk winter on Idaho's Sand Creek winter range. Elk from the Sand Creek Herd Unit migrate both north to summer ranges in southwestern Montana and east into the western portion of Yellowstone National Park. Another estimated 8,700 elk winter in four other herd units (Tex Creek, Palisades/Swan Valley, Fall River, and the Crow, Stump, and Freedom Creek herd units) in the Targhee and Caribou National Forests in proximity to Idaho's eastern border. Elk from these herds are less migratory than the Sand Creek Herd and interact to a much lesser degree with Wyoming elk on summer ranges along the Idaho-Wyoming border. No Idaho elk has tested positive for antibodies to brucellosis.

### **BRUCELLOSIS IN OTHER WILD UNGULATES**

Bovine brucellosis only rarely occurs in deer, pronghorn, and mountain sheep and any infection in these species is inconsequential to the management of brucellosis-affected bison and elk populations. Brucellosis has not been documented in any of these species within the GYA. When brucellosis occurs in moose, the disease appears to be systemic and typically causes death.

### **ECONOMIC CONSEQUENCES OF BRUCELLOSIS**

Brucellosis has several economic consequences for the livestock industry. Calf production is reduced in affected cattle herds because infected females typically abort their first pregnancy. Infections reduce

subsequent herd fertility. When infected females carry pregnancies to term, the resulting calf may be weak, unhealthy, and/or infected with *B. abortus*. Milk production is reduced in affected dairy herds.

The primary economic consequences to the industry in the United States are three-fold. In addition to production losses, significantly increased operating costs result from the various measures required to eradicate *B. abortus* from this country. Also, producers who sell cattle in international markets must comply with brucellosis-related importation requirements of these countries. Eradication of brucellosis generally is accomplished through the combined application of disease surveillance, vaccination, herd quarantine, herd management, blood testing of suspect herds and the slaughter of test positive and infected animals, depopulation of affected herds, and restrictions on sale of cattle into national and international markets.

Costs to producers for participation in the national program are less in states that are classified free of brucellosis. Cattle of the three states that contain the GYA, Montana, Wyoming, and Idaho are designated as brucellosis-free. Wyoming and Montana obtained their Class Free status in 1985 and Idaho in 1990. Producers in free states are able to ship their cattle interstate to national and international markets with minimal program restrictions. Countries that have successfully eradicated brucellosis also have eliminated the costs associated with surveillance, testing, quarantine, and vaccination.

## **BRUCELLOSIS ERADICATION**

A brucellosis vaccine (Strain 19) has been developed for use in cattle. The primary use of this vaccine is to increase herd immunity. On average, it is 65 - 70% effective in cattle. The effectiveness of strain 19 in captive bison is less than that for cattle. Moreover, at the experimental doses that have been used, strain 19 induces infection and abortion when administered to pregnant bison. The effectiveness in elk is under continuing investigation, but preliminary results suggest the efficacy of strain 19 in elk is similar to that of cattle and that the seroprevalence among mature elk cows has declined following 12 years of vaccination with biobullets at one Wyoming feedground.

Vaccination with strain 19 is important to managing the risk of transmission, but it will not alone eliminate *B. abortus* from elk in the GYA. Experience on 16 elk feedgrounds in Wyoming indicates that nearly 100% of calves can be vaccinated relatively economically and easily, although vaccination of elk at all 22 state feedgrounds may not be possible. Routine tests for *Brucella* antibodies cannot distinguish between animals that have been exposed/infected with field strain brucellosis and those which have been vaccinated with Strain 19. However, it may be possible to distinguish the two strains with additional tests and by considering the herd history.

Another vaccine, strain RB51, is currently under study for use in elk and bison. Strain RB51 has been licensed as a calfhood vaccine for use in cattle. Strain RB51 is similar to strain 19 in imparting resistance to infection and abortion in cattle and is preferred because the diagnostician may differentiate the field strain from the vaccine strain. However, an initial trial with strain RB51 in captive, pregnant bison caused some to abort, when given at a dose and inoculation route that had been safe in hundreds of pregnant cattle. Strain RB51 has not yet been demonstrated to be safe and effective for use in wild bison and elk.

Test and slaughter of infected animals, adult and calfhood vaccination, herd management and quarantine are part of the established protocol under the UM&R for eradication of brucellosis in cattle and bison. Various presumptive tests are used to identify herds that may have been exposed to *B. abortus*. Additional tests are used to determine which suspect herds actually contain brucellosis-infected animals. When an exposed herd is identified, the entire herd is quarantined and all eligible animals are tested. The herd blood test must include all test eligible animals which are six months of age and older except steers, spayed heifers, official calfhood vaccinates of the dairy breeds under 20 months of age and official calfhood vaccinates of beef breeds and bison that are less than 24 months of age. Official calfhood vaccinates that are pregnant or have previously calved also must be included in the blood test, regardless of age. All reactors are branded, tagged and sent by permit directly to slaughter. In brucellosis-free states like Montana, Wyoming, and Idaho, state livestock officials might wish to depopulate entire affected herds

rather than risk losing their class-free status. When a decision is made to depopulate an entire herd, federal and/or state funds may be available to compensate the producer for a portion of the loss.

According to the UM&R, a herd may not be released from quarantine until testing has been sufficient to demonstrate that the herd no longer harbors brucellosis or the entire herd has been sold to slaughter under permit. Test eligible cattle and bison in the herd are tested at 30-day intervals and all animals classified as reactors are shipped to slaughter. Two consecutive negative herd blood tests are required for release from quarantine, with the first negative herd blood test occurring 30 days or more after all reactors have been removed. The second herd test, the releasing herd test, must occur 180 days or more after all reactors have been removed. The releasing test must include all non-neutered cattle and/or bison over six months of age. In addition to these requirements, all states require an additional test of all non-neutered animals over six months of age, either between six and 12 months after an affected herd has been released for quarantine or between 10 and 16 months after the last reactor has been removed. All calves in an affected herd are included under the quarantine restrictions. If the heifer calves are retained in the herd, they should be vaccinated while calves. Calves may be removed only if they are neutered or for direct shipment to slaughter. After weaning, heifer calves must be quarantined, separate from the affected adult herd, until they test negative following completion of their first calving. If the heifer calves remain in the affected adult herd, the entire herd shall not be released from quarantine until all the heifer calves have matured and calved. Then the entire herd must be tested negative to qualify for quarantine release. If, during the testing periods, any of the animals are classified as reactors, those animals are removed and the 30-day testing procedure would begin again.

Methods for brucellosis eradication from wildlife, using current cattle technology, would include a combination of testing and removal of all animals classified as test reactors and vaccination of the herd with a safe and efficacious vaccine. With these methods, brucellosis has been successfully eliminated from captive bison herds in other national and state parks. However, test and removal of reactor animals in the GYA could result in the slaughter of substantial numbers of bison and elk, particularly feedground elk.

## **RISK OF TRANSMISSION**

There is considerable disagreement regarding the risk of *B. abortus* transmission from bison and elk to domestic livestock; the applicability of information derived from studies of the disease in domestic bison and cattle; and appropriate methods for the conduct of additional research to determine the risk of transmission. However, there have been no controlled field studies, specific to the GYA, to determine either the mechanism of *B. abortus* transmission from bison and elk to livestock or the frequency of brucellosis-induced abortions.

Most of the knowledge about brucellosis has been developed from studying the disease in cattle and captive bison. A limited amount of published information has been developed from controlled and field studies of brucellosis in bison. Brucellosis may behave differently in cattle than in bison. It is known that the infection behaves differently in chronically affected herds as compared to cattle or captive bison herds that experience a new outbreak of the disease. Chronically affected bison and cattle have a lower frequency of brucellosis-induced abortions because they have higher immunity in response to frequent exposure to non-infectious doses. Chronically affected herds also have lower calving rates than naive herds.

Regulatory officials have concluded that wild elk or bison were the probable source of *B. abortus* infection for cattle on six Wyoming premises in the GYA. Five of these premises were located west of the continental divide and one east of the continental divide. Extensive epidemiological evidence, including complete testing of herds associated with the affected premises, ruled out domestic livestock as the source. Based on the epidemiology, it was concluded that the most probable source for four of the premises was elk, and on the remaining two elk or bison. Two of these instances have occurred since Wyoming was classified as brucellosis-free in 1985. The last affected premise, which was the one located east of the continental divide, required the testing of approximately 5,000 head of cattle in eight herds epidemiologically associated with it. There was no evidence of infection in any of the eight herds. Regulatory officials concluded that the source of infection for this herd was either elk or bison. Ongoing surveillance and testing of cattle herds in the GYA revealed no additional affected premises. These findings

support the conclusion that cattle were not the source of *B. abortus* in any of the six affected premises. One case of brucellosis transmission from elk to a horse has occurred on a state feedground in Wyoming. It is not possible to quantify the risk of *B. abortus* transmission from bison and elk in the GYA to domestic livestock because most of the variables that define risk are unknown. Were such determinations possible, its value would be limited because there is no meaningful way to define acceptable risk. Although it is not possible to quantify the risk of transmission, it is possible to identify the various factors, which affect risk, and to qualitatively evaluate how alternative management approaches affect those factors. Important factors include:

1. Risk of transmission is affected by the degree of association between potentially infectious and susceptible animals. To become infected, a susceptible animal must come in contact with an infectious animal or discharges that contain a sufficient dose of viable *Brucella* organisms. Separation in space and time reduces the potential for transmission. In addition to separation that occurs as a result of management actions, separation may occur as a result of differences in behavior, habitat selection, geographic features and distribution in response to weather.
2. The risk of *B. abortus* transmission increases as the number and density of infectious animals in the host population increases. Conversely, the risk is reduced when the number of infectious animals is reduced through reduction in animal crowding, reduction in population size, and vaccination.
3. The risk of transmission increases as the number of susceptible animals that may associate with infectious animals increases.
4. The risk of transmission is affected by environmental factors. Outside of its host, the *Brucella* organisms have limited viability. Discharges remain infectious for longer periods during cold weather. Direct sunlight quickly kills the organism. Scavenging by wildlife reduces the occurrence of infectious tissues, but scavengers may also transport infected tissues.
5. The risk of transmission is affected by the class of the infectious animals. The available evidence indicates that nay risk of *B. abortus* transmission from bison to cattle is almost certainly confined to contamination by a birth event by adult females. However, limited data exist documenting the presence of *B. abortus* organisms in bison semen. Therefore, the risk of transmission from bull bison, though logically small, cannot be entirely eliminated based on existing information. Neutered animals are unlikely to transmit the disease.
6. The risk of transmission may be reduced by vaccination, neutering, and herd management.
7. Susceptibility varies among species. Some animals also are naturally resistant to infection.
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The risk of *B. abortus* transmission from bison or elk to domestic livestock is greater today than it was prior to 1967. Until 1967, bison numbers were controlled by periodic reductions and movements from the Park were infrequent. There were more than 1,000 bison on the northern range in the 1930's and almost 1,500 by 1954. After subsequent reductions, there were fewer than 400 bison in the entire park in 1967. The bison herd has since increased to about 3,900 in 1995. Bison now move from Yellowstone National Park into Montana and Wyoming with greater frequency and in larger numbers. Similar increases in numbers have occurred in elk populations throughout the GYA.

While the risk may be greater now than prior to 1967, the risk of transmission still is considered to be low. The opportunities for transmission have been negligible because the bison management programs have not permitted bison to freely associate with domestic livestock during high-risk periods.

Transmission of *B. abortus* from infected elk to susceptible cattle has been demonstrated in controlled studies under confined conditions. Transmission is most likely to occur when cattle and elk occur in close association and an infected cow elk aborts. Such circumstances could occur during late winter/early spring if infected elk feed with cattle. However, transmission is less likely to occur as a result of normal calving because elk do not normally associate with cattle during calving.

Areas in the GYA where transmission could occur are winter and spring ranges for elk and bison in proximity to the feedground complex in Wyoming. Neither species is in contact with cattle on either the National Elk Refuge or the state feedgrounds or on winter ranges in Grand Teton National Park or the



Bridger-Teton National Forest. However, elk may occasionally feed with livestock on private lands in winter.

Distributions of elk, bison, and cattle overlap on a few summer cattle grazing allotments in Grand Teton National Park. Cattle also share ranges with calving elk on Forest Service and Bureau of Land Management allotments and private rangelands throughout the GYA. There is potential for *B. abortus* transmission from elk to cattle whenever they occur together on elk calving range.